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Recovery and range expansion of the once critically endangered Mercury Islands tusked wētā (*Motuweta isolata*) on Ohinau Island, New Zealand, 16-years post-translocation

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Abstract

Facing the possibility of extinction, three Mercury Island tusked wētā (*Motuweta isolata*), one male and two females, were translocated in 1998 from Ātiu/Middle Island into captivity to initiate a captive rearing program. Over a period of nine years, their offspring were translocated to multiple islands off the Coromandel Peninsula, Aotearoa/New Zealand. Following the release of *M. isolata* onto Ohinau Island in 2007, surveys during the first five years post-release showed a limited range expansion of approximately 100 m from the release site, putting the longevity of the translocated population into question. Here, we report on the now island-wide range expansion of translocated *M. isolata* on Ohinau Island recorded during annual seabird monitoring trips to the island from 2016 to 2023 (9 to 16 years post-translocation). We also document the scavenging of seabird carcasses as a food source in this species. Additional follow-up surveys across the rest of the Mercury Islands and standardized surveys on Ohinau Island are warranted to quantitatively determine the long-term translocation success and ultimately the recovery of the species from near extinction.

Keywords

Anostostomatidae, diet, drought, establishment, orthopteran, seabird, translocation

Introduction

Introduced mammalian predators (e.g., rats *Rattus* spp., mustelids *Mustela* spp., cats *Felis catus* Linnaeus, 1758 etc.) have had a devastating effect on Aotearoa/New Zealand's biota, leading to several extinctions within incredibly short timeframes (Daugherty et al. 1993, Holdaway 1999). Wētā (Orthoptera: Anostostomatidae) are among New Zealand's endemic invertebrate fauna that have been particularly affected by introduced predators (Daugherty et al. 1993, Gibbs 1998b). This group of charismatic invertebrates are typically large-bodied, nocturnal, and flightless, and, along with many of New Zealand's iconic species, at risk of extinction (Daugherty et al. 1993, Gibbs 1998b, Trewick et al. 2012, 2022). Translocations to predator-free islands and/or mainland 'predator-proof' sanctuaries play a critical role in protecting some of the most vulnerable species from extinction (Watts et al. 2008). However, not all translocations are successful (Watts and Thornburrow 2009), and for some translocated wētā species, such as the Mercury Islands tusked wētā (*Motuweta isolata* Johns, 1997), information regarding post-translocation establishment is lacking (Stringer et al. 2014).

The tusked wētā group represents an unusual lineage of Anostostomatidae that has evolved exaggerated 'tusk'-like mandible appendages (Trewick and Morgan-Richards 2004). The tusks, present only in the final male instar, are secondary sexual characteristics used in intra-sexual competition (Field and Deans 2001, Winks et al. 2002, Burge 2005, Guignion 2005). Three species of tusked wētā are found in New Zealand: Raukūmara (*M. riparia* Gibbs, 2002), Northland (*Anisoura nicobarica* Ander, 1932), and the largest at up to 70 mm in body length, *M. isolata* (Gibbs 2002, Winks et al. 2002). All three species are nocturnal and primarily carnivorous, with *M. riparia* and *M. isolata* found foraging on the forest floor and the *A. nicobarica* being entirely arboreal (Gibbs 1998a, McIntyre 1998, Sherley 1998).

Motuweta isolata is believed to have occurred throughout the entirety of the Mercury Islands group (a series of seven main islands located off the Coromandel Peninsula, New Zealand; see Fig. 1) as well as on the adjacent mainland when sea levels were ~150 m lower than they are today (Hayward 1986, Towns et al. 2016). However, the last remaining population of tusked wētā became restricted to one of the smallest islands in the group, Ātiu/Middle Island, which is ~13 ha (McIntyre 2001). Surveys of Middle Island indicated a dwindling *M. isolata* population that was at risk of

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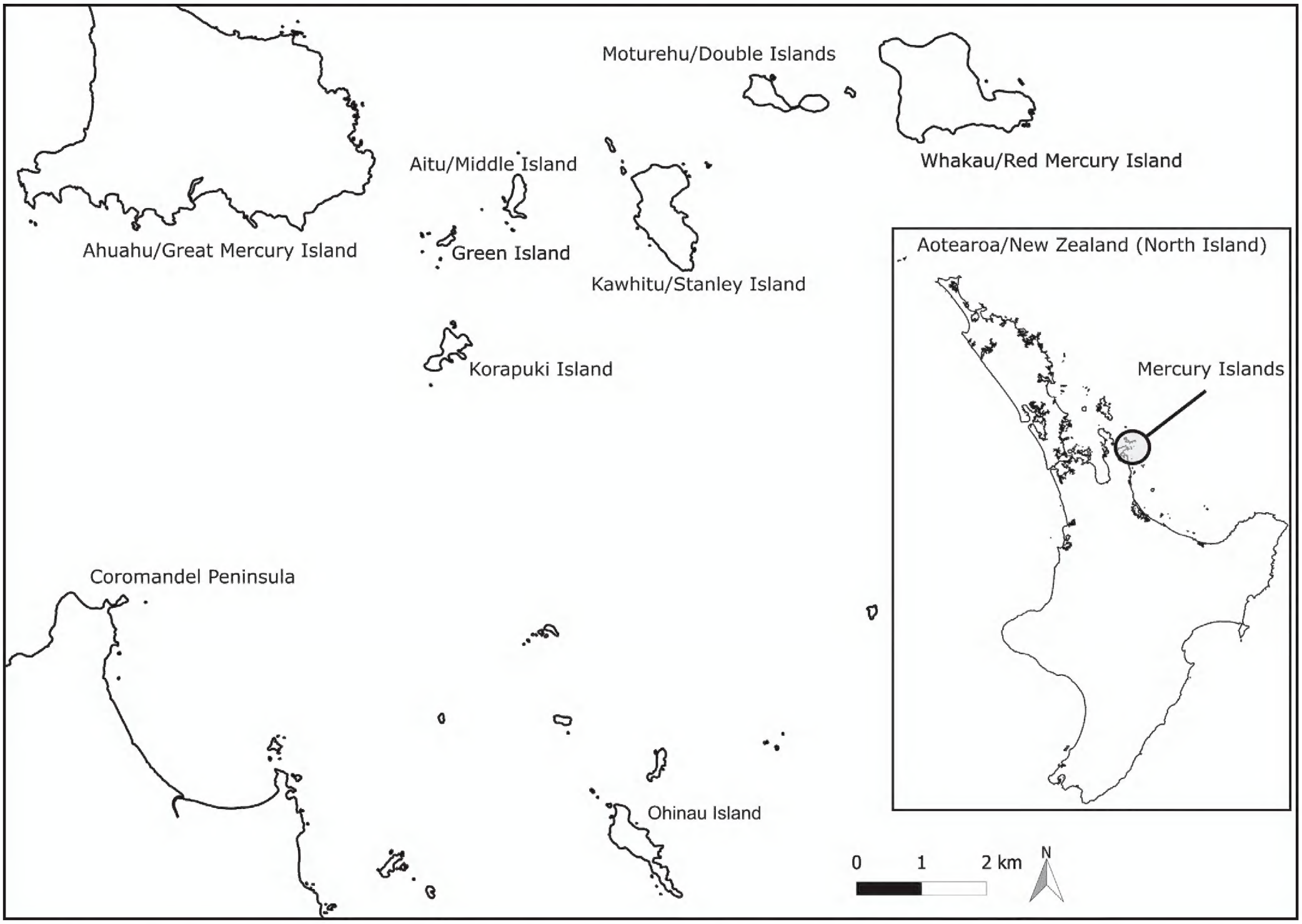

Fig. 1. Map of the Mercury Islands and Ohinau Island. Inset map showing location of Mercury Islands (highlighted in gray) in relation to North Island of Aotearoa/New Zealand.

extinction without conservation intervention, prompting the classification of 'Critically Endangered' under the New Zealand threat classification system (McIntyre 2001, Hitchmough et al. 2007). The presumed extinction of *M. isolata* across all other Mercury Islands is hypothesized to be a result of introduced mammals, as there is no history of introduced mammals making it to or being released on Middle Island (Atkinson 1964). Green Island (~3 ha) was also never invaded by mammalian pests, but it is unclear whether *M. isolata* were ever present on the island (Atkinson 1964).

Considering the species' extinction risk, a translocation and captive rearing program was initiated with three *M. isolata* (one male and two females) translocated into captivity in 1998 (Winks et al. 2002). Their offspring were subsequently released, over a period of nine years, onto multiple islands (where successful invasive mammal eradications had since taken place) within the Mercury Islands (Stringer and Chappell 2008, Stringer et al. 2014). Unfortunately, repeated follow-up surveys on Middle Island have indicated that the species is now most likely extinct from its translocation source (Stringer and Chappell 2008, Stringer et al. 2014). Of the six islands to which *M. isolata* were released, establishment has been successful at two (Whakau/Red Mercury Island and Korapuki Island), and at three islands (Ohinau Island, Moturehu/Double Islands and Kawhitu/Stanley Island) *M. isolata* managed to survive up to five years post translocation (Stringer et al. 2014). On one island (Repanga/Cuvier Island), it is unclear whether *M. isolata* managed to survive after the first translocation, but they were detected one year after the second translocation (Stringer et al. 2014). Following these management actions, the species' New Zealand conservation status has dramatically improved from 'Threatened - Critically Endangered' to 'Threatened - Nationally Increasing' (Hitchmough et al. 2007, Trewick et al. 2012, 2022). However, on many of these islands, surveys have indicated a limited range of expansion, suggesting that while the translocated wētā populations are still present, they may not yet be self-sustaining (Stringer et al. 2014). This includes Ohinau Island, where monitoring using tracking tunnels in 2011 and 2012 showed that the captive reared population that was released onto the island in November 2007 (100 individuals, 44 males, and 56 females of at least 1.5 cm in body length; Stringer and Chappel 2008) had only dispersed 60–100 m from the southern release site (Stringer et al. 2014).

Here, we report on the now island-wide range expansion of translocated *M. isolata* on Ohinau Island, recorded during annual seabird monitoring trips to the island from 2016 to 2023 (9 to 16 years post-translocation). We document how the population's range expanded on the island from its initial translocation site. We also report on an unusual component of the *M. isolata* diet that may have aided its successful establishment on the island as well as on the population's response to a drought event, a factor thought to underlie the species' extinction from Middle Island.

Methods

Study site.—Ohinau Island (36.7277°S, 175.8800°E; Fig. 1) is a ~43 ha island located ~5 km off the east coast of the Coromandel Peninsula off northern New Zealand. Ohinau Island is owned by local iwi (tribe) Ngāti Hei and is co-managed with the Department of Conservation (DOC) with access to the island restricted to permit holders conducting scientific research. The island supports a high diversity of species, particularly burrow-nesting seabirds. The island is forested, with a canopy consisting predominantly of māhoe (*Melicytus ramiflorus* J.R. Forst and G. Forst, 1776), māpou/red matipo (*Myrsine australis* (A.Rich.) Allan, 1947), and pōhutukawa (*Metrosideros excelsa* Sol. ex Gaertn., 1788). In 2005, the island was cleared of kiore/Pacific rat (*R. exulans* Peale, 1848) and European rabbits (*Oryctolagus cuniculus* Linnaeus, 1758; Chappell 2008).

The goal of the expeditions to Ohinau Island was to conduct research on the breeding demographics of toanui/flesh-footed shearwater (*Ardenna carneipes* Gould, 1844), a colonial, burrow-nesting seabird. Five of the 12 colonies on the island have been monitored since April 2016 (most recent trip occurred in December 2023), with visits to the colony occurring one to two times a year; one visit usually occurs during the egg-laying/incubation period (approximately a 2–3-week trip) in December/January and the other during the late chick rearing/chick fledging period in April/May (approximately 1–2-week trip; see Mischler 2016, Crowe 2018, 2020, Crowe and Bell 2019, Crowe and Burgin 2021, Burgin and Ray 2022 for more details).

Range expansion of tusked wētā on Ohinau Island.—To understand how the range of the *M. isolata* on Ohinau Island may have expanded since the previous surveys took place in 2011 and 2012 (Stringer et al. 2014), we report the presence of *M. isolata* throughout the monitored seabird colonies from sightings made by members of the seabird monitoring team since the monitoring program commenced in May 2016. These include nocturnal sightings of *M. isolata* made during searches of the seabird colonies as well as sightings of *M. isolata* found inhabiting seabird burrows during the day. *Motuweta isolata* were either found within the nesting chamber or within an excavated gallery dug out by the insect, the location of which was typically underneath a removable wooden hatch (installed for easier retrieval of the seabird during monitoring) or at the entrance of the burrow. As the primary aim during nocturnal searches was to capture and band (ring with a uniquely numbered metal band) flesh-footed shearwaters, we limited our searches only to flesh-footed shearwater colonies and the tracks between colonies. Additionally, because the soil of certain sections of the island are highly friable and densely burrowed (the risk of collapsing burrows being high), we avoided these areas entirely during the night.

Results

Contemporary and historical sightings.—Our sightings of *M. isolata* from both nocturnal observations and those seen within seabird burrows indicate that the translocated population has now clearly expanded from its initial release site in 2007 (Fig. 2). Though not all seabird colonies were able to be searched at night (due to the friable nature of the soil and risk of damage to the seabird colonies), *M. isolata* were found in burrows in all monitored seabird colonies when burrows were investigated during the day.

At the commencement of the seabird monitoring study in 2016, *M. isolata* were only frequently seen in the southernmost seabird colony, and on very few occasions they were encountered in the central seabird colony (PC and MB, pers. obs.; Fig. 2). At that time, the density of *M. isolata* appeared to be higher near the release site and decreased toward the northern end of the southernmost seabird colony (PC and MB, pers. obs.; Fig. 2). From 2017 onwards, observations of *M. isolata* further away from the release site became more frequent (PC, pers. obs.; Fig. 2). In 2018, *M. isolata* were sighted in the westernmost colony as well as on the track that joined the westernmost and southernmost colony (MB, pers. obs.; Fig. 2). In 2018, *M. isolata* were occasionally observed at all monitored seabird colonies (except for the most northern colony) but remained common only at the southernmost seabird colony (PC, pers. obs.; Fig. 2).

In 2020, a single *M. isolata* was sighted at the temporary camp used by researchers (PC, pers. obs., Fig. 2), the furthest distance (~830 m) they have been seen from the release site. In 2022 and 2023, *M. isolata* were encountered more frequently at the camp site as well as within the northernmost colony. In all other monitored seabird colonies, *M. isolata* continued to be found regularly (Fig. 2).

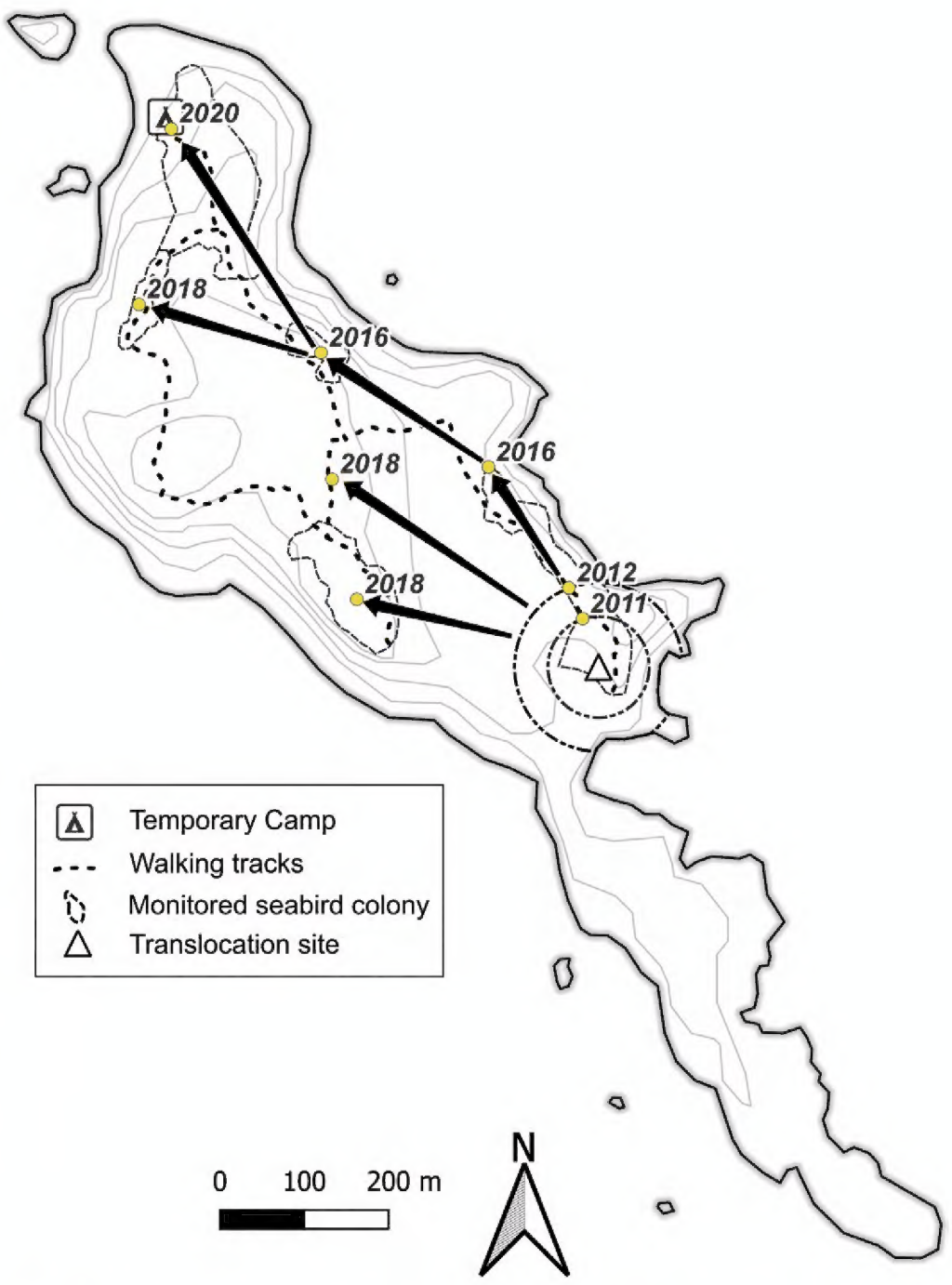

Fig. 2. Map of *Motuweta isolata* sightings and range expansion on Ohinau Island. Estimated range expansion of *M. isolata* identified from the seabird monitoring team between 2016 to 2020 from the translocation site (triangle). The concentric circles from the translocation site represent the farthest reported distance from the release site: 60 m in 2011 and 100 m in 2012 (Stringer et al. 2014). The large-dotted line indicates walking tracks used by the seabird monitoring team to navigate to each colony. The small-dotted outlines indicate the monitored seabird colonies. The camp symbol represents the location of the temporary camp used during each seabird monitoring trip.

Tusked wētā scavenging on dead seabirds.—In May of 2019, while conducting a nocturnal search for seabirds at the southernmost monitored seabird colony, on numerous occasions the field team observed *M. isolata* scavenging on the carcasses of dead seabird chicks (primarily dead flesh-footed shearwater and occasionally on ōi/grey-faced petrel (*Pterodroma gouldi* Hutton, 1869, PC, pers. obs.; Fig. 3).

Drought event.—In the austral summer of 2019/2020, a severe drought event occurred over the North Island (NIWA 2020), resulting in the die-off of extensive sections of the māhoe forest on Ohinau Island (see Crowe and Burgin 2021 for more details). For the six weeks the seabird monitoring team was stationed on the island (3 to 27 January and 10 to 28 February 2020), there was zero precipitation (Crowe

Fig. 3. Photo of *Motuweta isolata* scavenging on a toanui/flesh-footed shearwater chick carcass in May 2019.

and Burgin 2021). The seabird monitoring team noted that as the drought progressed through January and into February, fewer *M. isolata* were sighted during nightly colony searches (PC, pers. obs.). In the final weeks of February, no *M. isolata* were sighted on the forest floor, including around the translocation site (PC, pers. obs.).

Discussion

Based on our observations, we strongly suspect that *M. isolata* have now recolonized the entirety of Ohinau Island following their translocation 16 years ago. Although we were unable to search the southern portion of Ohinau Island, it is highly probable that the dispersal pattern in the south of the island mirrors that of the north, given that *M. isolata* were seen routinely as far away as the temporary camp at the northern end of the island (Fig. 2).

The northward expansion of the population from the release site appears to have been a slow gradual process until very recently when *M. isolata* began appearing more frequently (and then more routinely) within all monitored seabird colonies (Fig. 2). Five years following their release on Ohinau Island, the population had expanded at least 100 m (Stringer et al. 2014), and while in 2016 (at the start of seabird monitoring, four years after the last standardized survey), *M. isolata* were sighted as far north as the central colony, they remained common only near the release site (Patrick Crowe, pers. obs.). The slow gradual dispersal followed by what appears to be a rapid expansion of the population out from the release site is a pattern observed on Red Mercury Island, where *M. isolata* were released in 2001 (Stringer et al. 2014). The translocated population took 8–9 years to disperse up to 180 m from the release site, which rapidly increased to an expansion rate of 50–100 m annually thereafter (Stringer et al. 2014). Another translocated species, Cook Straight giant wētā (*Deinacrida rugosa* Buller, 1871), has also repeatedly exhibited similar dispersal patterns after having been shown to have limited dispersal after release (Meads 1992, Watts et al. 2009, 2011, 2017). Interestingly, the slow expansion occurs despite the considerable mobility demonstrated by radio-tracking (Stringer and Chappell 2008, Watts et al. 2011, 2012). Stringer et al. (2014) postulated that the *M. isolata* re-colonization process is potentially density dependent, with the population expanding rapidly only once a certain density threshold is reached.

An additional factor that may have contributed to the successful establishment on Ohinau Island may be the absence of many native predators that are common throughout the archipelago. For instance, ruru/morepork (*Ninox novaeseelandiae* Gmelin, 1788), a native owl whose diet is principally invertebrates (Haw and Clout 1999), is detected infrequently and in low numbers on the island (Crowe 2019, Burgin 2021, 2022, Lamb 2023). Other large nocturnal predators that are present throughout the archipelago, but not on Ohinau Island, include tuatara (*Sphenodon punctatus* Gray, 1842), and kiwi pukupuku/little spotted kiwi (*Apteryx owenii* Gould, 1847, Moeed and Meads 1987, Cree et al. 1995). Only Duvaucel's gecko (*Hoplodactylus duvaucelii* Duméril & Bibron, 1836), which is now present at high densities on Ohinau island (SL, pers. obs.), may potentially predate on *M. isolata*. Populations of other forest-dwelling reptiles, such as the common gecko (*Woodworthia maculata* Gray 1845) and the diurnal moko and copper skinks (*Oligosoma moco* Duméril & Bibron, 1839, and *O. aeneum* Gerard, 1857, respectively), persist on the island in very low numbers (Hoare et al. 2007, Miskelly 2014, SL, pers. obs.), making them unlikely to be a factor influencing *M. isolata* expansion. Within six months following the 2005 kiore eradication on Ohinau Island, the capture rate of Duvaucel's geckos increased by 400% (Hoare et al. 2007), but expansion from their northwestern enclave around the temporary camp had not occurred by 2014 (Miskelly 2014). Since then, Duvaucel's geckos have expanded rapidly southward and are present throughout all monitored seabird colonies (SL, pers. obs.). Interestingly, on Matiu/Somes Island in Wellington harbor, Watts et al. (2017) reported a southward population shift in the distribution of Cook Strait giant wētā that correlated strongly with the northward detection of geckos. However, the authors also noted that a causative change attributable to an expanding gecko population (as well as factors that could have played a role in the range shift, e.g., habitat change) is not clear, and more research is needed to quantify this relationship. This creates an open question as to how the population dynamics of *M. isolata* and Duvaucel's geckos may or may not influence each other in the future. Furthermore, it will be interesting to discover how much of an impact native predators actually have on *M. isolata* establishment and expansion considering that the little spotted kiwi and tuatara now co-occur with *M. isolata* on other islands they were translocated to (Moeed and Meads 1987, Cree et al. 1995, Subramanian et al. 2015).

Motuweta isolata scavenging upon seabird carcasses is, to our knowledge, unreported in this species, but was hypothesized by Winks et al. (2002). Little is known about the *M. isolata* diet. In general, they are regarded as opportunistic carnivores that primarily prey on insects, including smaller *M. isolata* (Sherley 1998, Winks et al. 2002). However, scavenging on dead seabirds is not specifically unique to *M. isolata* and has been reported in the Snares Island ground wētā (*Anderus subantarcticus* Salmon, 1950), a ground wētā that inhabits Snares Island (located in the subantarctic; Butts 1983). Opportunistic carrion feeding is not unusual for Orthopterans in general (Martin-Vega et al. 2013), and sampling for Orthoptera in the wild can often involve carrion-baited traps (Martin-Vega et al. 2013, Cadena-Castañeda et al. 2019, Vergara et al. 2020). For instance, squid-baited pitfall traps applied in a New Zealand forest resulted in a four-times increase in ground wētā captures compared to standard pitfall traps (Vergara et al. 2020). Thus, where omnivorous/predatory wētā coincide with a high-seabird abundance, the opportunity to engage in the necrophagy of seabirds may be a more common feature of their diet.

Burrowing seabirds provide critical ecosystem services at their breeding colonies by transporting and depositing marine-derived nutrients in the form of guano (including additional materials such as feathers, eggshells, and carcasses; Anderson and Polis 1999, Bancroft et al. 2005, Ellis 2005, Zwolicki et al. 2013, Zmudczyńska-Skarbek and Balazy 2017). Moreover, seabirds, through their burrowing behavior, 'engineer' the soil, creating a multitude of complex underground nesting chambers forming retreats that allow other animals to utilize, as well as modify, the physical and chemical properties of the soil (Bancroft et al. 2005, Orwin et al. 2016). Indeed, as observed here and reported in the Snares Island ground wētā and the Snares Island cave wētā (*Insulanoplectron spinosum* Richards, 1970), *M. isolata* utilize seabird burrows as daytime retreats or as spaces to dig out their galleries (Butts 1983). Through these ecosystem services, seabirds shape the invertebrate communities of their breeding colonies (Bassett et al. 2014, Orwin et al. 2016); thus, we speculate that the island-wide expansion of tusked wētā on Ohinau Island (and probably on other islands they have been released on) has likely benefited, at least initially, from the presence of burrowing seabirds.

Motuweta isolata are hypothesized to be highly sensitive to drought events, and this is speculated to be the reason that *M. isolata* disappeared from Middle Island (Stringer et al. 2014). Surveys on Red Mercury Island, where water is a more permanent feature,

found that *M. isolata* were more abundant in survey plots that were closer to streams (Stringer and Chappell 2008), suggesting that *M. isolata* have a greater affinity for moister environments. Indeed, the sister species of *M. isolata*, *M. riparia*, are confined to stream banks and, as an escape response, will leap into and submerge themselves in water (McIntyre 1998, Gibbs 2002). McIntyre (1998) further speculated that *M. isolata* may be essentially 'marooned' in the generally drier and potentially more unfavorable Mercury Islands' climate. As Ohinau Island lacks a permanent source of water (though after periods of heavy rainfall, ephemeral pools and streams can form), Stringer et al. (2014) suggested that prolonged drought events may put the future of the Ohinau Island population at risk of extinction. In the austral summer of 2019/2020, a severe drought event occurred on Ohinau Island, causing extensive sections of the māhoe forest to die off (Crowe and Burgin 2021). The seabird monitoring team noted that as the drought progressed through January and into February, *M. isolata* were sighted with decreasing frequency during nightly colony searches (PC, pers. obs.). In the final weeks of February, no *M. isolata* were seen on the forest floor including around the translocation site (PC, pers. obs.). Emergence by *M. isolata* (among other factors) depends upon rainfall and/or high humidity (McIntyre 1994, Gibbs 2001); thus, it is unsurprising that *M. isolata* accordingly decreased their activity patterns during the drought. It is unknown how the drought on Ohinau Island impacted their survival, but in the years since, *M. isolata* have managed to persist and have continued their population expansion, suggesting that *M. isolata* may be able to hunker down during long dry episodes until unfavorable conditions pass.

Overall, our findings indicate that *M. isolata* have now likely recolonized the entirety of Ohinau Island through a pattern of slow incremental expansion followed by a rapid northward expansion. A sufficient passage of time has occurred for *M. isolata* on the other translocated islands to have significantly expanded from their release sites. Our data are opportunistic sightings; thus, standardized surveys across Ohinau Island to corroborate our findings and across the rest of the translocated islands are recommended to understand the long-term fate of this species. Basic knowledge of *M. isolata* biology, such as micro-habitat preferences and seabird interactions, is needed to inform future conservation efforts.

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